Genetic-Control of Phosphorus-Metabolism In Sheep

GENETIC CONTROL OF PHOSPHORUS METABOLISM IN SHEEP

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Balance studies with chimaera-derived sheep have provided good evidence for genetic control of phosphorus metabolism. Plasma concentrations, urinary and endogenous fecal excretion and efficiencies of absorption of P were similar within but different between four sets of triplets. The results were confirmed with a larger group of chimaera.

Key words: Chimaera, sheep, phosphorus, genetics, metabolism

There are a number of reports of individual differences in P metabolism characterized by differences in urinary P secretion. The first detailed evidence of genetic control was the observation by Field and Suttle (1979) that urinary P excretion differed more greatly between than within monozygotic twin cattle. The advent of chimaera-derived sheep of very similar genotype presented an opportunity to investigate the role of genetics in controlling P metabolism.

True absorption and excretion of P by four sets of chimaera triplets were measured in two experiments. In the first the sheep were given a pelleted cereal-based diet supplemented to contain 1.5, 3.1 or 6.2 g P and 3.4 or 5.4 g Ca/kg DM in a factorial design (Field et al. 1983). In each set of chimaeras, triplets were assigned at random to the P treatments and each triplet received its allocated P treatment with Ca treatments in two consecutive radioactive balance trials. Different patterns of P metabolism were seen between the sets of triplets (Table 1); for instance, those sets which absorbed P with high efficiency had higher plasma P concentrations, urinary excretion and lower fecal endogenous P. The efficiencies of absorption of total P were very similar within but markedly different between ($P<0.001$) sets of triplets. The routes of excretion of increased quantities of surplus P from the body varied with the efficiency of absorption of dietary P by the sets; the fecal route alone was demonstrated by the least efficient pair, the urinary alone by the most efficient and the feces and urine by the intermediate pairs.

In the second experiment the availability of P in 12 common feedstuffs was measured. Each feedstuff was consumed by one member of each set of triplets with each member of a set consuming four feedstuffs in total in a series of four radioisotope trials. The efficiency of absorption varied significantly with the diet ($P<0.001$) and the set of triplets ($P<0.001$). The sets ranked in the same order as in experiment 1 on 9 of the 12 diets.

Balance trials were also carried out with 13 sets of chimaera-derived lambs; 8 sets of twins, 3 of triplets, 1 of quadruplets and qunitruplets and 3 singles. The sheep received ad libitum a complete pelleted diet and the amount of variation in plasma concentration and urinary excretion of P between sets as a proportion of total variation (H^2) was calculated before and after correction for DM intake. Adjusted value for plasma concentration was 0.82 ($P<0.01$) and for urine excretion 0.69 ($P<0.01$). The former should be compared with an estimate of 0.364 for the additive genetic contribution (h^2) of total variation measured in a grazing flock of sheep (Woolliams et al. 1984). The difference between the estimates is caused by the effect of dominance and epistasis. Thus total variation in plasma P appears to be approximately equally

Table 1. P metabolism of chimaera sheep meaned over treatments

Triplet set	Plasma (mmol/L)	Excretion (g/day)		Efficiency of absorption
		Urinary	Endogenous fecal	
1	2.55	0.81	0.96	0.74
2	2.00	0.10	1.25	0.62
3	2.87	1.35	0.59	0.84
4	2.95	1.12	0.76	0.82

divided between additive genetic, non-additive genetic and environmental variance. From the balance trials there appeared to be a strong genotypic-relationship between plasma P and the efficiency of absorption of P so it is likely that the efficiency of absorption also exhibits an approximately equal partition of genetic variation between additive and non-additive.

It is the study of genotypic relationships rather than environmental relationships that will allow the construction of safety factors in the dietary requirement of P for ruminants. In dietary experiments the use of chimaera animals avoids the largest component of individual variation and so permits an efficient comparison of treatment within sets, the efficiency increasing with the size of set.

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